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REVISED FINAL REPORT

OSHAWA SKEET & GUN CLUB
PHASE I BIOAEROSOL STUDY

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Prepared for

Ontario Ministry of the Environment
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1.0 INTRODUCTION

The Oshawa Skeet and Gun Club (OS&GC) is located at the base of the Oak Ridges Moraine, on Lots 4 and 5, Concession 9 in the City of Oshawa. The OS&GC has a sound attenuation berm constructed with paper fibre biosolids (PFB), or paper sludge, mixed with sand. The PFB material is 25% clay, 25% paper fibre and 50% water. The PFB material is obtained from Atlantic Packaging Products Ltd. (APPL) by Courtice Auto Wreckers, who mix this material on-site with sand to produce a product they call "Sound-Sorb™". The berm at the OS&GC is crescent-shaped, and is approximately 90 m long, 20 m wide, and 15 m high, and measures approximately 45 m in length along the interior perimeter, and 250 m in length along the exterior perimeter. The berm is estimated to contain 27,000 m^3 of material (Sporometrics, 2003; MOE, 2002).

APPL obtained a certificate of approval to spread paper sludge on agricultural land in Durham County.[1] This practice, as well as the use of PFB in sound attenuation berms, like the one at the OS&GC, has been highly controversial. Opponents to these uses of paper sludge have expressed concerns related to the presence of ink and dye residues, chemicals used in de-inking and processing, as well as dioxins and acrylamide, in the PFB. Concern has also been expressed regarding the potential for Bioaerosols to be released from mould growing on the berms.

GLOBALTOX was retained by the Ministry of the Environment (MOE) on June 24, 2002 to conduct an investigation to identify the microbial populations established in the berm and in the PFB materials (including Sound-Sorb™), and further, to identify by-products which can form aerosols. **GLOBALTOX** sub-contracted **Sporometrics** to conduct the sampling, culturing and identification of micro-organisms present in the berm at the OS&GC.

The purpose of the present study is to:

1. Review the existing information regarding the chemical and biological composition of the OS&GC berm; and

2. To conduct a study to determine which micro-organisms are present in the berm that have the potential to release bioaerosols from the surface of the berm.

This report replaces the Final Report issued by **GLOBALTOX** on October 31, 2003. Additional information requests were received from the Bioaerosol Committee, and incorporated into the report. All changes to this report have been approved by the MOE.

[1] Ontario Ministry of the Environment (MOE), Media Backgrounder, March 1999. Atlantic Packaging Receives Two-Year Approval to Apply Paper Sludge on Agricultural Land.

2.0 METHODOLOGY

2.1 Literature Review

The following documents were provided by the MOE for GLOBALTOX'S review:

- Ontario Ministry of the Environment and Energy (2003a) Atlantic Packaging Products Ltd. Paper Fibre Biosolids and Sound-Sorb™ Berm, Oshawa Skeet and Gun Club: Results of Chemical and Microbiological Testing - Addendum

- Ontario Ministry of the Environment and Energy (2002) Atlantic Packaging Ltd. Paper Fibre Biosolids and Sound-Sorb™ Berm, Oshawa Skeet and Gun Club: Results of Chemical and Microbiological Testing;

- Gartner Lee Limited (2001) Sampling and Analysis of Paper Sludge at Oshawa Skeet and Gun Club;

- Voroney, R.P. (2001) Atlantic Packaging Products Ltd. Final Report – Paper Fibre Biosolids Benefits Study;

- 2CG Waste Management Consulting Services (2000) Microbiological Analysis of Fresh, Stockpiled and Land Applied Bulk Paper Biosolids (PFB) Samples;

- Gartner Lee Ltd. (1993) Leachate Quality from Paper Sludge Atlantic Packaging's Paper Fiber Soil Enrichment Program

- Ontario Ministry of the Environment (2003b) Chemical and Microbiological Test Results of Sound-Sorb™ Groundwater Impact Study at the Oshawa Skeet and Gun Club, Sweep 1 February/March 2003.

In addition, the following correspondence and documentation received from the Bioaerosol Committee members were also reviewed by GLOBALTOX.

- Protect the Ridges (August 8, 2003) Presentation to Ms. Helen Gurlensky, Ontario Ministry of the Environment.

- Protect the Ridges (2003) Chronology – April 2000 – August 2003.

- Reilly, M (August 15, 2003) Email to Keith West *et al.* "Test Result for PFB and Sound-Sorb™".

- Reilly, M (August 9, 2003) Email to Tony Wong, Durham Region "Groundwater Contamination at Sound-Sorb™ site".

- Reilly, M (August 8, 2003) Letter to Gord Miller, Environmental Commissioner of Ontario "Sound-Sorb™ Groundwater contamination results withheld".

- Reilly, M. (August 1, 2003) Email to Dr. Mark Goldberg, GlobalTox International Consultants Inc. "Disease from heat-treated sludge".

- Reilly, M. (February 1, 2003) Email to Ms. Dumais, Ministry of the Environment "Disclose complete test results".

- Reilly, M. (February 11, 2003) Email to Dr. Mark Goldberg, GlobalTox International Consultants Inc. "Acrylamide and Gases".

- Reilly, M. (January 27, 2003) Email to Ms. Dumais, Ministry of the Environment "Follow up on Sound-Sorb™".

- Reilly, M. (January 9, 2003) Email from Martin Fever to Mr. Peter Lapp "Application for Review of the Policy Regarding the use of Sound-Sorb™".

- McParland, D. (October 21, 2002) Workplace Safety and Insurance Board – Appeals Resolution Officer Decision

- Reilly, M (April 23, 2001) "History of Respiratory Difficulties and Cases from Land Applied Paper Mill Sludge in Ontario".

- Balaban, P. (December 5, 2002) Email to Deb Vice "Updates".

- Vice, D. (December 6, 2002) Email to Committee "Update/MOE/Sound-Sorb™".

- Sludgewatch (October 10, 2002) Email to Dr. Mark Goldberg, GlobalTox International Consultants Inc. "SludgeWatch ECO Annual Report – Sound-Sorb™ Berms".

- Reilly, M. (September 14, 2002) Email to Anne Neary et al. "Sierra Club Commentary – GlobalTox Memo Sept. 6th".

- Reilly, M. (September 14, 2002) Email to Ms. Dumais et al. "Bioaerosols – No protocol provided to Bioaerosols Committee".

- Ontario Out of Doors (May, 2002) News – Gun-Club Hassles.

- Vice, D. (September 19, 2002) Email to Peter Balaban et al. "PTR Response/Bioaerosol Study".

- Reilly, M. and M. Beatty (September 19, 2002) Email to Committee "Response from Marilyn Beatty – Brock Land Stewards".

- Reilly, M. (September 18, 2002) Email to Peter Balaban et al. "Testing Sound-Sorb™ at Various Stages of Decomposition".

- Reilly, M. (August 30, 2002) Email to Ernie Eves et al. "Problems with MOE staff and Lab Intimidation – E. coli in Paper Sludge".

- Wilson, R. G (March 22, 2002) Letter from Canadian Association for Environmental Analytical Laboratories to Brian Ward.

The documents listed above were reviewed by **GLOBALTOX**. The existing chemical and biological data characterizing PFB in the berm material were reviewed and summarized to gain insights into identifying species which are most likely to contribute to bioaerosols, and those substances which, if emitted to air, have the greatest potential to represent a concern from a human health perspective. This task was focused on two areas:

1. ***Chemical Constituents (non-microbiological origin):*** Chemical constituent concentrations within the berm and PFB were summarised and compared to appropriate criteria (in the absence of regulatory values specific to PFB material), including Table A generic criteria and Table F "background" criteria outlined in the *Guideline for Use at Contaminated Sites in Ontario* (MOE, 1997).

2. ***Microbiological Constituents:*** The available information on microbiological species identified in the berm material were examined for the purpose of determining the species most likely to be associated with bioaerosol formation.

2.2 Sporometrics Study (Sporometrics, 2003)

An initial meeting was held on August 1, 2002 with the Bioaerosol Committee to review the design of the study as described in this proposal and identify potential improvements.

The document *Sampling Protocol – Sound-Sorb™, Oshawa Skeet and Gun Club Bioaerosols Assessment, Phase I* outlines the procedures employed by **Sporometrics** during the field sampling and laboratory analysis (enclosed as Appendix I). **GLOBALTOX** and **Sporometrics** were given access to the OS&GC site on November 14, 2003 to sample the berm. In addition, **Sporometrics** also sampled the Sound-Sorb™ berms at the East Elgin Sportsmens' Association (EESA) , and surface samples from the Harmony Road Compost Site (HRC) on April 24 and April 25, 2003.

Please refer to the **Sporometrics** report for additional information regarding the final sampling methodology and analysis employed at all sites.

3.0 RESULTS

3.1 Literature Review

All of the reports outlined in 2.1[2] were reviewed in detail in relation to the chemical and microbiological components of the PFB material and the Sound-Sorb™ berm.

The various reports indicate that several substances were present at levels above those recommended in various regulatory guidelines. In one instance, a substance of concern (acrylamide monomer) was reported to be present, however, there is no relevant guideline available for comparison. A comparative summary of all chemical parameters detected in PFB and Sound-Sorb™ reported to be in excess of at least one guideline[3], as reported in all of the documents reviewed, is presented in Table 1. In the absence of specific criteria for chemical parameters in PFB, Table A and Table F values for soil are applied for comparison purposes only. A summary of the chemical parameters detected in liquid is presented in Table 2.

A summary of the results of the first sweep of groundwater sampling are presented in Table 3 along with a comparison to relevant regulatory guidelines (Table A guideline for potable groundwater, Ontario Drinking Water Standards,). In addition, a summary of all microbiological parameters evaluated within the reports is provided in Table 4.

[2] Voroney (2001) was found to not contain information relevant to this investigation, and therefore has not been summarised.

[3] Where a substance was reported to be in exceedance of a regulatory value in one report, it was included. It should be noted that not all values presented in this table are necessarily in exceedance, as the various reports sampled different media or areas of the berm, and the analysis was completed by various individuals. Values determined to be in higher than appropriate guidelines are shown in **BOLD**. Appropriate guidelines that are exceeded are also shown in **BOLD**.

Table 1: Comparison of Relevant Regulatory Values and Various Levels of Chemical Constituents Detected in Paper Fibre Biosolids (PFB), Sound-Sorb™ and Related Samples

Parameter	Criteria		Sample Matrix		Location	Reference
	Table A	Table F	PFB	Sound-Sorb™		
Acrylamide	NA	NA	9 µg/g dw	< 0.1 – 0.36 µg/g dw	OS&GC	MOE (2003a); MOE (2002)
			< 0.1 µg/g dw	< 0.1 µg/g dw	East Elgin	MOE (2003a)
Aluminum	NA	30,000 µg/g dw	3,540 – 4,860 µg/g dw	3,670 – 6,800 ug//g dw	OS&GC	MOE (2003a); MOE (2002)
			NA	2,900 – 3,830 µg/g dw	OS&GC	Gartner Lee (2001)
			NA	NA	OS&GC	Gartner Lee (1993)
			8,200 µg/g dw	5,500 – 8,400 µg/g dw	East Elgin	MOE (2003a)
Iron	NA	35,000 µg/g dw	374 – 474 µg/g dw	2,900 – 13,000 µg/g dw	OS&GC	MOE (2003a); MOE (2002)
			NA	1,980 – 3,440 µg/g dw	OS&GC	Gartner Lee (2001)
			NA	NA	OS&GC	Gartner Lee (1993)
			1,100 µg/g dw	700 – 3,400 µg/g dw	East Elgin	MOE (2003a)
Phosphorus	NA	NA	0.48 – 0.50 mg/g dw	0.6 – 0.98 mg/g dw	OS&GC	MOE (2003a); MOE (2002)
			NA	407 – 464 µg/g dw	OS&GC	Gartner Lee (2001)
			NA	ND	OS&GC	Gartner Lee (1993)
			0.78 mg/g dw	0.65 – 0.79 mg/g dw	East Elgin	MOE (2003a)
Phenols	NA	NA	NA	NA	OS&GC	Gartner Lee (1993)
Toluene	**2,100 ng/g dw**	**2 ng/g dw**	**190 – 350 ng/g dw**	**< 10 – 140 ng/g dw**	OS&GC	MOE (2003a); MOE (2002)
			NA	< 0.02 µg/g dw	OS&GC	Gartner Lee (2001)
			< 10 ng/g dw	< 10 ng/g dw	East Elgin	MOE (2003a)
Total Xylenes	**25,000 ng/g dw**	**2 ng/g dw**	**200 – 460 ng/g dw**	< 10 ng/g	OS&GC	MOE (2003a); MOE (2002)
			NA	< 0.02 ppm dw	OS&GC	Gartner Lee (2001)
			< 10 ng/g dw	< 10 ng/g dw	East Elgin	MOE (2003)
Zinc	600 µg/g dw	160 µg/g dw	51 – 81 µg/g dw	19 – 102 µg/g dw	OS&GC	MOE (2003a); MOE (2002)
				63 - 76 µg/g dw	OS&GC	Gartner Lee (2001)
			62 µg/g dw	41 – 130 µg/g dw	East Elgin	MOE (2003a)
TPH (heavy, C16-50)	**1,000 µg/g dw**	NA	ND	**3,400 µg/g dw**	OS&GC	MOE (2002)
			11,000 µg/g dw	**7,600 – 13,000 µg/g dw**	East Elgin	MOE (2003a)

NA= Not Available
dw= dry weight

Table 2: Comparison of Relevant Regulatory Values and Various Levels of Chemical Constituents Detected in Surface Liquid at the Oshawa Skeet and Gun Club (OS&GC) (Gartner Lee,2001)

Parameter	PWQO	Liquid	Location
Aluminum	0.075 mg/L	**45.5 mg/L**	OS&GC
Iron	0.3 mg/L	**59.3 mg/L**	OS&GC
Phosphorus	0.03 mg/L	**11.8 mg/L**	OS&GC
Phenols	0.001 mg/L	NA	OS&GC
Toluene	0.8 µg/L	NA	OS&GC
Total Xylenes	NA	ND	OS&GC
Zinc	0.03 mg/L	**0.64 mg/L**	OS&GC
TPH	NA	ND	OS&GC

NA Not Available
ND Not Detected

Table 3: Comparison of Relevant Regulatory Values and Various Levels of Chemical Constituents Detected in Groundwater Samples taken during Sweep 1 from the Oshawa Skeet and Gun Club, Harmony Road Compost and Ambrose Aggregates Sites (MOE, 2003b)

Parameter	Criteria		Groundwater (ng/L unless otherwise indicated)											
	Table A (potable groundwater)	**ODWS**										
			MW1	**MW2**	**MW3**	**MW4**	**MW5**	**MW6**	**MW7**	**MW8**	**MW10**	**MW11**	**MW12**	**MW13**
Acrylamide	NA	NA	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	12,000 ng/L	NA	260	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	**200 ng/L**	NA	**380**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	**200 ng/L**	NA	**410**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	**200 ng/L**	NA	**360**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	NA	10 ng/L	**440**	**46**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(e)pyrene	NA	NA	430	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	NA	NA	420	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	130,000 ng/L	NA	980	ND	ND	ND	150	ND	ND	ND	ND	ND	ND	ND
Perylene	NA	NA	100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	NA	NA	320	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	63,000 ng/L	NA	900	ND	ND	ND	270	ND	ND	ND	ND	ND	ND	ND
Pyrene	40,000 ng/L	NA	950	ND	ND	ND	110	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	NA	NA	480	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate + Nitrite	**11 mg/L**	**11 mg/L**	3.56	0.007	2.88	0.056	3.54 mg/L	3.58 mg/L	**30.6 mg/L**	1.39 mg/L	2.04 mg/L	4.56	2.25	**19.6**
Nitrite	1 mg/L	1 mg/L	0.005	ND	0.005	0.025	0.006 mg/L	0.005 mg/L	0.004 mg/L	0.007 mg/L	0.028 mg/L	0.002	0.005	0.004
Light Petroleum Hydrocarbons	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heavy Oils	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total coliform	NA	0 CFU/100 mL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Escherichia coli	NA	0 CFU/100 mL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

MW9 and MW14 -no data was provided in the report .
ND: Not Detected
NA: Not Analysed/Available

Table 4: Summary of Various Microbiological Parameters Detected in Samples of Paper Fibre Biosolids (PFB) and Sound-Sorb™

		Sample Matrix						
Parameter	**Criteria**	**Fresh PFB**	**Stockpiled PFB**	**Sound-Sorb™**	**Leachate**	**Liquid**	**Location**	**Reference**
Total aerobic bacteria and fungi	NA	93×10^6 CFU/g	$0.0028 \times 10^6 - 470 \times 10^6$ CFU/g	300×10^6 CFU/g	NA	NA	OS&GC	2CG (2000)
Total thermophilic fungi – *Aspergillus fumigatus*	NA	$<0.0001 \times 10^6$CFU/g	$< 0.0001 \times 10^6$ CFU/g	300×10^6 CFU/g	NA	NA	OS&GC	2CG (2000)
Total Gram Negative Bacteria	NA	3.3×10^6 CFU/g	$0.0001 \times 10^6 - 160 \times 10^6$ CFU/g	3×10^6 CFU/g	NA	NA	OS&GC	2CG (2000)
Total Coliform	NA	$6.7 \times 10^6 - 2.6 \times 10^7$ CFU/g	NA	$1.0 \times 10^3 - 3.6 \times 10^4$ CFU/g	NA	NA	OS&GC	MOE (2003a); MOE (2002)
	NA	ND	NA	$1.4 \times 10^3 - 9.7 - 10^3$ CFU/100 mL	NA	9.0×10^5 CFU/100 mL	OS&GC	Gartner Lee (2001)
Endotoxin	NA	5 µg/g	0.2 – 2.5 µg/g	0.7 µg/g	NA	NA	OS&GC	2CG (2000)
Fecal *Streptococci*	NA	$1.0 \times 10^4 - 3.0 \times 10^4$ CFU/g	NA	$< 1.0 \times 10^1$ CFU/g	NA	NA	OS&GC	MOE (2003a); MOE (2002)
Fecal Coliform	Class A: Class B:	ND	NA	NA	NA	4.0×10^4 CFU/mL	OS&GC	Gartner Lee (2001)
Escherichia coli	NA	$2.6 \times 10^5 - 5.0 \times 10^5$ CFU/g	NA	$< 1.0 \times 10^1$ CFU/g	NA	NA	OS&GC	MOE (2003a); MOE (2002)
	NA	ND	NA	NA	NA	1.0×10^4 CFU/100 mL	OS&GC	Gartner Lee (2001)
	NA	3.8×10^4 CFU/g	NA	$< 1.0 \times 10^1$ CFU/g	NA	NA	East Elgin	MOE (2003a)
Pseudomonas aeruginosa	NA	$23 - 6.2 \times 10^3$ CFU/g	NA	$< 1.0 \times 10^1$ CFU/g	NA	NA	OS&GC	MOE (2003a); MOE (2002)

NA= Not Available
ND= Not Detected
CFU= Colony Forming Units

MOE (2003a) and MOE (2002) – Oshawa Skeet and Gun Club, Oshawa, Ontario

Fresh PFB (estimated at 2-3 days old) was sampled in October, 2001 at the Whitby Atlantic Packaging plant, from a storage bunker in which the PFB is stored prior to transport. Core samples were also taken from the Sound-Sorb™ berm at the OS&GC in November, 2001.

Test results from PFB material sampled from APPL showed that concentrations of toluene, xylenes and ethylbenzene were higher than Table F values, which represent the typical background found in Ontario on undeveloped pristine land. It is based on the OTR 98, which is the 98th percentile of the levels detected in typical background Ontario soil. It is noted that Biosolids Guidelines, when they exist, are typically higher than Ontario Typical Range (OTR) levels. Copper and sodium were also above Table F background criteria, but were below the Biosolids Guidelines. Acrylamide monomer was detected in one sample of PFB at a level of 9 µg/g. Generic criteria and background levels for acrylamide in Ontario soil have not been derived to date, however, the MOE interpreted this level as being 'low'. *E. coli* levels in the PFB were lower than the United States Environmental Protection Agency (US EPA) guideline for Class B biosolids of $< 2 \times 10^6$ CFU/g (40CFR503.32).

In the Sound-Sorb™ berm at OS&GC, Total Petroleum Hydrocarbons (TPH) were present at levels above the Table A criterion for heavy hydrocarbons (1,000 µg/g), and lower than the guideline derived by the Canadian Council for Ministers of the Environment (CCME) for heavy hydrocarbons in fine textured soil (6,400 µg/g). Due to the significant clay composition of the berm, the berm material would be classified as fine textured. All other parameters were below Table A guidelines. Toluene, free cyanide and chloride were all lower than Table F levels (MOE, 2002). Acrylamide monomer was determined to be present in one sample of the berm material, at a level of 0.36 µg/g.

There is evidence of significant microbial activity in the OS&GC berm, as indicated by the reduction of organic carbon and the high temperature levels (78 °C). *E. coli* levels were determined to be below the detection limit.

Chlorophenols, nonylphenol ethoxylates, and PCBs were not assayed in any sample during the 2001 analysis, although they were previously detected in 1998. Microbiological parameters, other than *E.coli* were not evaluated. TPH was not measured in fresh PFB material. Polycyclic aromatic hydrocarbons (PAH) were not measured in background or surface level Sound-Sorb™. The only sample analysed for PAH was from a depth of 80 cm. Volatile organic compounds (VOCs) were measured at 24, 45 and 80 cm below the berm surface, but not at 10 cm. In addition, the sample for background level VOCs was taken at 42 cm only.

Neither air nor groundwater samples were taken from the OS&GC site, so it is not possible to assess whether the berm is affecting either media based on this study.

MOE (2003) – East Elgin Sportsman's Association Gun Club, Aylmer, Ontario

Two Sound-Sorb™ berms at the East Elgin Sportsman's Association Gun Club were sampled in August, 2002. One berm was constructed in March, 2002 and the other was 3- to 4-weeks old at the time of sampling.

TPH was detected at a level of 11,000 µg/g in the fresh PFB material. Acrylamide monomer was also detected at a level of approximately 0.1 µg/g in the PFB material.

E. coli was detected only in the PFB sample from the 3- to 4-week old berm.

Copper was detected in the berm material at levels above OTR levels, however, these levels were below Table A guidelines. TPH was detected in the berm material at levels of 7,600 (6-month old berm) and 8,200 - 13,000 µg/g (1-month old berm), however, volatile organic carbons and chlorophenols were not detected in any of the Aylmer berm samples. Acrylamide monomer was detected at approximately 0.1 µg/g in the 6-month old berm. *E. coli* was not detected in the Sound-Sorb™ berm material (e.g. <10 Colony Forming Units (CFU)/g).

Only one sample of fresh PFB was analysed, so it is difficult to know whether the results of this analysis are representative.

MOE (2003b) Groundwater Test Results

The MOE conducted the first 'sweep' of groundwater sampling in February/March 2003 from test wells located at the OS&GC, HRC and Ambrose Aggregate Pit (AAP). Fourteen test wells have been drilled: monitoring wells (MW) 1-4 are located at the OS&GC; MW 5-9 are located on the HRC site; and MW 10-14 are located at the AAP. Details regarding sampling methodology, soil composition, and analytical methodology were not provided, as only tabular analytical results were provided to **GLOBALTOX**.

Table 4 above presents a summary of analytical results for various select chemical parameters. **GLOBALTOX** has compared the analytical results of this study against two relevant guidelines: Table A generic criteria for use in a potable groundwater situation (*Guidelines for Use at Contaminated Sites in Ontario, Ontario Ministry of the Environment;* MOE, 1997), and Ontario Drinking Water Standards (MOE, 2002a). Provincial Water Quality Objectives (PWQO) are not appropriate for comparison to the monitoring well results, as PWQO are intended for application to surface water (not groundwater). PWQO values are protective of aquatic organisms and recreational uses of surface water, and are not specifically developed for the protection of human health.

Anthracene and benzo(a)anthracene were both detected at levels less than the corresponding Table A criteria at MW1.

Benzo(a)pyrene was detected at levels in excess of the ODWS at MW1 and MW2. However, this substance was not detected at any other MW. Benzo(e)pyrene was detected in MW1; however no regulatory value is available for evaluation of this substance.

Benzo(b)fluoranthene and benzo(k)fluoranthene were detected in MW1 at a level greater than the corresponding Table A criteria. Fluoranthene was detected in MW 1 at a level less than its Table A criterion.

Chrysene, perylene and benzo(g,h,i)perylene were each detected in MW1, however no Table A groundwater criteria or ODWS are available for evaluating these findings. In addition, pyrene was detected in both MW1 and MW5, however there is no regulatory value to use as a comparison for this substance. The structurally-related substance Indeno(1,2,3-c,d)pyrene was detected only at MW1, and there is no regulatory value available for comparison.

Phenanthrene was detected at levels greater than the Table A guideline at both MW1 and MW5.

Combined nitrate and nitrate levels were in excess of both the related Table A guideline and ODWS at MW7 and MW13. Nitrite levels at both of these wells were below the related regulatory values, indicating that nitrate levels are increased in these samples. It should be noted that nitrates can be naturally present in groundwater as a result of the decay of plant and animal materials, agricultural fertilizers and geological characteristics of soil (MOE, 2001). Neither of these test wells are located at the OS&GC.

Acrylamide, *E. coli* and total coliform were not detected in any of the MW samples.

The Table A and ODWS values employed in the comparative analysis of the groundwater results are both health-based criteria. Of the MW samples in the vicinity of the OS&GC taken in Sweep 1, benzo(b)fluoranthene and benzo(k)fluoranthene were the only two substances detected in excess of Table A values, and benzo(a)pyrene was in excess of ODWS value.

No data are available for MW9 or MW14, as samples were not available from these wells during Sweep 1.

Gartner Lee (2001) – Oshawa Skeet and Gun Club, Oshawa Ontario

Ten test pits (1.5 m depth) were dug within the berm with a backhoe. The compost cover was removed from the sampling areas before the pits were dug. Samples were taken from the south side of the berm, with five test pits dug on the western half and five test pits on the eastern half. These samples were sorted, and combined to produce two composite samples representing the western and eastern sections of the berm. Samples were also taken from the puddles originating from the berm drainage.

Visual observations indicated that sand (fine-coarse) had been mixed with the grey PFB material. In a test pit in the west section of the berm, a tree stump and wood were present in combination with the PFB. Isolated layers of fine, dark material were also observed.

Total coliforms in the PFB samples were 1,400 – 9,700 CFU/100 mL, and 900,000 CFU/100 mL in the liquid sample. Fecal coliforms were not detected in the PFB material, but were found in the liquid at 40,000 CFU/100 mL with *E. coli* being detected at 10,000 CFU/100 mL. *Aspergillus* and *Stachybotrys* species were not detected in any samples.

The report concluded that although some infiltration may occur, it is unlikely that significant amounts of leachate would be formed from the berm. Bacterial and fungal agents were determined not to be of concern. However, the quality of the liquid coming from underneath the berm was questionable. Levels of boron, chromium, copper, molybdenum, lead and zinc in this liquid were higher than in the berm leachate. The authors of Gartner Lee (2001) suggest that the presence of E. coli and fecal coliform in the liquid were indicative of a material, such as sewage sludge, that may have been disposed of near the base of the berm. **GLOBALTOX** is of the opinion that the Gartner Lee (2001) does not provide sufficient detail with respect to sampling methodology or results for **GLOBALTOX** to make any comment regarding the potential origin of bacterial organisms detected in the sample of surface water assessed.

2CG (2000) – Atlantic Packaging Products Ltd. (APPL) and Oshawa Skeet and Gun Club

Four bulk samples of PFB were collected on March 14, 2000 from the surface of PFB piles. The four piles were of different ages, and included PFB that was freshly discharged from the manufacturing system, PFB stockpiled for 4 months (Stockpile 4), PFB stockpiled for 8 months (Stockpile 8), and land-applied PFB (location not cited) after 5.5 months. Several microbial parameters were assessed in this study: Total aerobic bacteria and fungi; Total speciation for *Stachybotras chartarum*; Total thermophilic fungi – speciation for *Aspergillus fumigatus*; Total Thermophilic *Actinomycetes;* Viable respirable gram negative bacteria; and endotoxin levels. Please refer to Table 2 above for a summary of the results.

There was evidence of microbial decomposition in Stockpile 8, but very little in Stockpile 4. All PFB samples had high moisture content (50-60%), indicating a lower potential for bioaerosolisation during application. All samples had a high carbon:nitrogen ratio, which would result in low microbial decomposition during stockpiling.

The authors compared the microbial levels detected to those observed in an independent bioaerosol testing study conducted at a leaf and yard waste composting facility (LYC) in Sarnia, Ontario in 1995. Microbial parameters examined in the Sarnia LYC study included: Total aerobic bacteria and fungi; Total thermophilic fungi; speciation for *Aspergillus fumigatus*; Total gram negative bacteria; and endotoxin. In general, the levels of total aerobic bacteria and fungi detected in the PFB samples were higher than the levels described in the LYC study, while levels of total thermophilic fungi, and *A.*

fumigatus were lower than those described in the LYC study. Total gram negative bacteria in the PFB were lower than the LYC levels, with the exception of one sample of PFB from the 8-month old stockpile. Levels of endotoxin were also lower in the PFB samples relative to the LYC results.

MOE Guidelines were not referred to within the report in relation to the PFB samples. No risk-based values were utilized in the interpretation of test results.

The report concluded that the study results indicate minimal potential for bioaerosol formation during land application of PFB.

Aspergillus fumigatus was identified in only one sample of land-applied PFB. *Actinomyces and Stachybotrys* were not isolated in any samples. Endotoxins were detected, indicating the presence of gram-negative bacteria. However, further detail regarding the characteristics of these endotoxins were not provided.

No conclusion was reached with regards to the levels and types of micro-organisms present in the PFB samples, other than the absence of *Aspergillus fumigatus,* and *Stachybotrys chararum.* However, the authors concluded that the levels in the PFB samples were lower than those detected in bulk samples in a previous study.

There were several flaws in the design of this study. Replicates and blanks do not appear to have been included. Results were not compared to either health based- or other regulatory guidelines. Therefore, the significance of the reported levels of bacteria and endotoxin is difficult to interpret. Also, air concentrations were not measured. Conclusions regarding respirable levels of detected substances cannot be made by either the authors or **GLOBALTOX.**

Gartner Lee (1993) – Oshawa Skeet and Gun Club

In November 1992, paper sludge samples were collected weekly from the Atlantic Packaging Products' facilities in Whitby and Scarborough. The weekly samples were combined to form a single monthly sample from each plant. Two tests were performed: a water leach test and an acid leach test.

Gartner Lee used a source-pathway-receptor framework (risk assessment approach) to evaluate the potential movement of the paper sludge material spread on agricultural land. The pathway evaluated by Gartner Lee was the potential flow of runoff from the paper sludge or erosion, and the receptors were aquatic organisms in a nearby watercourse. The source (paper sludge) was considered to be solid, and was not expected to be mobile during normal runoff events. It was assumed that only under intense rainfall would the paper sludge material be potentially eroded with soil. The report concluded that it was "unlikely that paper sludge itself would be washed into an adjacent watercourse and it is appropriate to look at the chemistry of runoff from paper sludge."

The report stated that analytical results from the distilled water leachate tests were considered to be the most predictive of runoff from the sludge, prior to dilution, while the analytical data from the acid leach test were used to predict worst-case conditions. The water leachate test results were compared with Provincial Water Quality Objectives

(PWQOs) released in October 1992. The PWQOs are based upon the protection of aquatic life (non-human organisms) and recreational uses of surface water bodies, and are not health-based criteria.

The water leachate test results exceeded the PWQOs for iron, zinc, phosphorus, and phenolic compounds. However, Gartner Lee noted that iron, zinc and phosphorus were typically attenuated in soils and in watercourse buffer strips and therefore, elevated levels of these substances were unlikely to runoff the source site during normal rainfall. The report stated that phenolic compounds are present in the natural environment due to the decay of organic matter typically at higher concentrations than would be expected from paper sludge material. Gartner Lee also noted that it is unlikely that these relatively low concentrations would impact nearby watercourses during a runoff event.

The Gartner Lee report identified that while the laboratory leachate test results can be used to determine the potential for impact to nearby watercourses by comparing predicted chemistry of the potential runoff to PWQOs, the quality of surface runoff actually reaching the watercourse would be influenced by other mechanisms such as dilution, plant uptake of nutrients and metals, and adsorption of metals and other parameters by soil particles and crop stubble or residue.

It is important to note that Gartner Lee (1993) leachate analysis is 10-years old and involved analysis of paper sludge material in a laboratory environment (field leachate data were not collected from land-applied material). Actual field leachate data would provide more relevant information on the leachate chemistry from the paper fiber material and its potential fate in the environment. Leachate generation and its environmental fate is primarily influenced by site-specific conditions such as organic carbon content, pH, and soil texture (that is, coarse-textured soils would allow greater percolation of water than fine-textured soil which tend to have tighter matrix). Also, the physical and chemical properties of the contaminants themselves influence the environmental fate process.

Finally, this test attempts to simulate in the lab, natural conditions. The study was done to help predict the potential for paper sludge spread on agricultural land to leach contaminants, which could impact nearby surface water. The relevance of this study to the OS&GC Sound-Sorb™ berm, which is composed of PFB in a solid matrix and is covered in a compost layer, is questionable.

3.2 Sporometrics Study (Sporometrics, 2003)

The results of the **Sporometrics** (2003) Bioaerosol Study entitled *A Microbiological Investigation of the Sound-Sorb™ Berm at Oshawa Skeet and Gun Club* have been included in this report as Appendix II. Please refer to this report for further details regarding methodology, analysis and conclusions. **GLOBALTOX'S** summary of this report is presented in Section 4.2 below.

4.0 ANALYSIS

4.1 Literature Review

Total Petroleum Hydrocarbons (TPH) was the only analyte reported to be in excess of the Table A guideline in berm materials at both the Oshawa and Aylmer sites. TPH was detected at 3400 µg/g in the OS&GC berm and 7,600 – 13,000 µg/g in the East Elgin berm. The fresh PFB sampled from the OS&GC by MOE (2002) does not appear to have been analysed for TPH. However, the fresh PFB material sampled in the East Elgin study was found to contain approximately 11,000 µg/g TPH. These findings suggest that the PFB materials coming from APPL contain TPH. The PFB material is waste from recycled paper. The TPH in the samples could be coming from ink that may not be completely removed during the de-inking process.

Acrylamide was detected in PFB and Sound-Sorb™ materials from both sites, indicating that the source of the material may be associated with the production of PFBs by APPL. However, no Ontario generic criteria are available to evaluate the acrylamide levels detected in the PFB and berm materials. Development of site-specific criteria would be necessary to permit an evaluation of the acrylamide results in relation to human health and/or environmental risk.

It is evident that various bacteriological species are present in both the PFB material and Sound-Sorb™ berm material. However, determining the levels of these organisms that pose potential risks to human health is difficult. Nonetheless, the results of the various studies indicate that the levels of bacteria or bacteria-related parameters (*E. coli*, *Pseudomonas*, fecal *Streptococci*, Total coliform and endotoxin) are lower in the Sound-Sorb™ material than in the PFB material. This suggests that the prevalence of these organisms/parameters may be decreasing over time *in situ*.

Based on the Sweep 1 groundwater results of MOE (2003b) it appears as though the sample taken from MW1, which is located near the OS&GC, contains a variety of polyaromatic hydrocarbons (PAH) that were not necessarily detected in any other MW samples.

MOE (2002) reports PAH data for only one sample from the OS&GC berm (80 cm depth). All PAH detected in this sample (phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, and benzo(g,h,i)perylene) were found to be less than the relevant Table A and Table F criteria. It should be noted that all of these substances were also detected in some groundwater MW samples as presented in MOE (2003b). Although MOE (2002) indicates that PAH are not susceptible to leaching from soils, the relationship between the presence of these substances in the berm and the groundwater warrants further observation. It does not appear as though PAH data were generated for any other OS&GC core samples or background control soil samples, so the PAH results of only core sample have been reviewed to date. Furthermore, PAH data are not available for either the EESA or HRC sites. Therefore it is not possible to assess the

potential impact of the PAH content of the berm material on groundwater based on the current data.

The Table A and ODWS values employed in the comparative analysis of the groundwater results are both health-based criteria. Of all of the MW samples, benzo(b)fluoranthene and benzo(k)fluoranthene were the only two substances detected in excess of Table A values, and benzo(a)pyrene and nitrate+nitrite levels were the only parameters in excess of ODWS values.

4.2 Sporometrics Study (Sporometrics, 2003)

Oshawa Skeet and Gun Club

About 35 species of fungi were observed in the samples from the OS&GC berm. In terms of the number and frequency of the fungi identified during this study, the levels detected are comparable to other media (eg. household dust) colonized by similar species of fungi (Scott, 2001). The fungus *Peziza* was observed on the faces of clefts in the OS&GC berm. This fungus is common in outdoor air during the growing season. Please consult Tables 2-5 and Appendix A of the **Sporometrics** report (Appendix II to this **GLOBALTOX** report) for additional details pertaining to these results.

Dominant fungi present in the berm were determined to be dry sporulating organisms. In particular, species of *Aspergillus, Cladosporium, Mucor* and *Penicillium* were identified, all of which have potential to contribute to bioaerosol formation due to their physical characteristics. It should be noted that *Aspergillus, Mucor* and *Penicillium* species are commonly found in forest and agricultural soils (Joffe and Borut 1966; Miller *et al.*, 1957). In general, the diversity of the types of organisms found in the berm decreased with depth.

The most significant organism identified by **Sporometrics** in relation to potential human health risks was *Aspergillus fumigatus*. The 2CG (2000) report was the only other study conducted at the OS&GC site that evaluated the presence of *A. fumigatus*, and the organism was found to be present at 4.8×10^3 CFU/g. In the **Sporometrics** study, *A. fumigatus* was detected in the range of $< 1 \times 10^3 - 33 \times 10^3$ CFU/g in only 14/45 samples, primarily between the depths of 0 – 5 cm. Only 3/15 samples taken from a depth of 50 cm were found to contain detectable levels of the organism. These data suggest that *A. fumigatus* is more abundant at the surface of the OS&GC berm. *A. fumigatus* is not uncommon in the natural environment, and is commonly found growing on compost (Sporometrics, 2003). An expert panel of scientists have established that there is minimal risk of potential infections from exposure to *A. fumigatus* in healthy individuals exposed to composting bioaerosols (Millner *et al.*, 1994).

Sporometrics observed during the first round of sampling that mature green waste compost[4] had been applied to the OS&GC berm as a topdressing material. It was

[4] 'Green waste compost' refers to composted lawn and yard waste

plausible that this material is a source of *A. fumigatus* in the berm, and additional study was undertaken to verify this. The HRC composting facility is located 2 km northeast of the OS&GC, and the potential for aerosol generation of *A. fumigatus* from this facility, and subsequent deposition at the OS&GC, is also significant. It was compost from this facility that was applied as topdressing to the OS&GC berm. Please refer to the section below with respect to the HRC sampling results.

Stachybotrys chartarum was detected in some of the OS&GC berm at sample depths 0 and 5 cm. *S. chartarum* is a strong decomposer of cellulose (Malloch, 1981) and has been isolated from paper products, textiles, seeds, soils and dead plant material (Saamson *et al.*, 1996). **Sporometrics** have reported this as a common species in water damaged building materials (very frequently from the cellulose layer of drywall, occasionally from pressed (wafer) board, and rarely from wood planks and beams). Isolates of this species are potential producers of satratoxins, a potent family of mycotoxins produced by several related species of microfungi (Saamson *et al.*, 1996). Accordingly, it is generally recommended that exposure to *Stachybotrys* be avoided (Saamson *et al.*, 1996).

Three bacteriological parameters were evaluated in the current study: Total coliform, *E. coli*, and *Salmonella*. Total coliform in the OS&GC berm were determined to range from $< 1 \times 10^3 - 51 \times 10^3$ CFU/g, and were detected in 39/45 samples. The distribution of the coliform bacteria appeared to be fairly consistent at the three sampling depths. In terms of Total coliform, the bacterial flora in the Sound-Sorb™ material is low, and is unlikely to significantly contribute to bioaerosol formation.

E. coli was detected in the OS&GC berm within the range of $< 1 \times 10^3 - 8 \times 10^3$ CFU/g, and was detected in only 8/45 samples. Two samples, from 0 and 5 cm, and six samples at 50 cm were found to contain *E. coli*. The results suggest that *E. coli* levels increase with depth in the berm. *Salmonellae* were not detected. There are no Canadian guidelines available for acceptable levels of these bacteria in soil. However, the United States Environmental Protection Agency (US EPA) has developed acceptable levels of fecal coliform in biosolids, as described in 40CFR503.32. Class A Biosolids (fecal coliform < 1,000 CFU/g) can be applied to land without any pathogen related restrictions. Class B Biosolids are classified as biosolids with fecal coliform $< 2 \times 10^6$ CFU/g. Provided that the appropriate restrictions are met, Class B biosolids may also be applied to land. The levels of *E. coli* detected in the Sound-Sorb™ berms at the OS&GC in the current study are below the US EPA Class B Biosolids requirements. In previous studies (MOE, 2003a; MOE, 2002), the *E. coli* levels detected were less than Class A guidelines. PFB applied to land would likely be considered as Class B biosolids. If so, then the bacterial levels within the OS&GC berm would meet the US EPA Class B guideline.

Soil, in general, acts as a barrier to the movement of pathogens (such as *E. coli*) which might leach to groundwater. This barrier action is attributable to the organic matter and clay compounds present in soil, which can filter, absorb and immobilize micro-organisms. In addition, soils may be subjected to physical, chemical, and biological conditions that can destroy pathogens (US EPA, 2000). Given the composition of the berm (organic matter and clay), the above processes may reduce any potential for leaching and/or exposure to pathogens within the berm.

Harmony Road Compost Site

The moisture content of the samples from this site were within the range of 2.5 – 45.5%. pH and temperature measurements were not taken from this site.

Compost heaps demonstrated significant variability with respect to age and composition, although all compost on the site was derived from plant materials. Fungal growth was evident on the surfaces of various compost heaps 16 fungal taxa were identified in the 6 cultured surface samples from the HRC site.

Total coliform was the only bacteriological parameter examined in the HRC samples, and ranged from undetectable to 51x 10^3 CFU/g, which is higher than samples from the EESA site, and comparable to the range identified in the OS&GC samples.

East Elgin Sportmen's Association Berm

At the time of sampling (April 2003), vegetation growth on the berm surfaces was minimal. Furthermore, there was no indication that plant compost had been applied to the EESA berms (in contrast to the OS&GC site). A few samples were taken from areas of conspicuous fungal growth. Identified species included: *Peziza, Lycogala epidendron,* and myxomycetes species.

A total of 6 fungal taxa were identified from the cultured EESA surface samples, including *A. fumigatus, A. terreus* and *Penicillium*. Of the 6, one taxa, zygomycetes, was unique to the EESA (i.e. not present at the other sites).

A 5 cm^2 patch of mould growth was also noted on the south berm of the 350 m range, and a sample was taken. This mould was identified as *Stachybotras chartarum*. However, *Stachybotras* species were not identified in any of the other EESA samples.

Total coliform was the only bacteriological parameter examined in the EESA samples, and ranged from undetectable to 15 x 10^3 CFU/g. Yeast was also detected.

Atlantic Packaging Products Site (Whitby)

The moisture content of the PFB material was determined to be 40.9%. pH and temperature measurements were not taken from this site during sampling (April, 2003).

There was no evidence of visible fungal growth on the piles of PFB at the facility. However, **Sporometrics** did note that microbial (sterile mycelial) growth was evident on the wall between access doors to the storage building on-site. This growth (on what was likely an old PFB sample) indicates that some microbial growth can occur on PFB before

being processed into Sound-Sorb™. No fungi were cultured from the single sample of fresh PFB.

Total coliform was the other bacteriological parameter examined in fresh PFB sample, and it was detected at 29 CFU/mg (dry wt). This level is higher than the range of Total coliform identified at the EESA samples, but is lower than the range detected in the OS&GC and HRC samples.

Table 5: Comparison of Surface Levels (0-5 cm) of Select[5] Microbiological Components of the Oshawa Skeet and Gun Club (OS&GC), East Elgin Sportsmen's Association (EESA), Harmony Road Compost (HRC), and Atlantic Paper Products Ltd. (APPL) Samples (Sporometrics, 2003)

	OS&GC	EESA	HRC	APPL
Number of Samples	15 (0 cm), 15 (5 cm)	3	6	1
Sample Type	Surface bulk	Surface grab	Surface grab	Surface grab
Number of fungal taxa identified	35	6	16	
Aspergillus fumigatus (CFU/mg)	3 – 597 (0 cm) 4 – 383 (5 cm)	6	387	ND
Aspergillus terreus (CFU/mg)	1-751 (0 cm) 2 – 74 (5 cm)	8	ND	ND
Aspergillus versicolor (CFU/mg)	NA	NA	14,286	NA
Chrysosporium (NOS) (CFU/mg)	NA	NA	446	NA
Doratomycetes stemonitis (CFU/mg)	1 -122 (5 cm)	ND	38	ND
Geomyces pannorum (CFU/mg)	1 (5 cm)	ND	26	ND
Geotrichum candidum (CFU/mg)	ND	NA	11 – 5,355	ND
Graphium (NOS) (CFU/mg)	44 (0 cm) 4 – 157 (5 cm)	33	42	ND
Mucor (NOS) (CFU/mg)	1 – 149 (0 cm)	ND	34 – 65	ND
Penicillium subgenus *B. verticillium* (CFU/mg)	780 (0 cm)	1	ND	ND
Scopulariopsis fusca (CFU/mg)	14	ND	3,571	ND
Stachybotrys chartarum (CFU/mg)	1 – 14 (0 cm) 157 (5 cm)	ND*	ND	ND
Sterile mycelium	11 – 558 (0 cm) 1 – 157 (5 cm)	ND	15 - 21	ND
Yeast	1 – 38 (0 cm) 1 (5 cm)	4 – 268	10 – 4,655	ND
Zygomycetes	ND	39	ND	ND
Total Coliform (CFU/mg)	< 1 – 11 (0 cm) 1 – 51 (5 cm)	< 1 – 15	< 1 – 51	29

NA: Not analysed
ND: Not detected
* *S. chartarum* was not quantitatively identified at EESA, however, this organism was qualitatively identified from a patch of visible growth on the EESA berm (Sporometrics, 2003)

[5] The parameters selected for comparison are all that were detected in EESA, HRC or APL samples. The levels detected in these samples are compared to levels detected at the OSGC site

Table 6: Abundance of Select Surface Fungi at the OS&GC, EESA, HRC and APPL Sites Relative to Other Habitats (Sporometrics 2003; Scott, 2001; Gochenaur 1978; Joffe and Borut; 1966).

	Average Abundance, (CFU/mg)				Reference Values (Avg. abundance, CFU/mg)		
Organism	**OS&GC**	**EESA**	**HRC**	**APPL**	**Forest Soil[a]**	**Agricultural Soil[b]**	**Household Dust [c*]**
Aspergillus fumigatus	94	6	387	ND	NA	<1	12 (118)
Aspergillus nidulans	250	ND	ND	ND	NA	3	5 (47)
Aspergillus niger	252	ND	ND	ND	NA	3	13 (714)
Aspergillus terreus	143	8	ND	ND	NA	<1	1 (2)
Cladosporium NOS	84	ND	ND	ND	NA	<1	12 (257)
Clonostachys rosea	138	ND	ND	ND	NA	<1	6
Fusarium cf. oxysporum	6	ND	ND	ND	NA	NA	15
Graphium/Doratomyces/Scopulariopsis	20	33	1332	ND	1	<1	1
Mucor NOS	-	ND	50	ND	1	<1	3 (43)
Penicillium Aspergilloides	143	ND	ND	ND	331	38	4 (241)
Phoma herbarum	29	ND	ND	ND	NA	NA	34 (976)
Stachybotras chartarum	47	ND	ND	ND	NA	<1	1 (5)
Sterile mycelium	81	ND	18	ND	NA	1	19 (235)
Trichoderma	16	ND	10	ND	NA	1	8 (102)
Yeast NOS	20	136	1249	ND	NA	NA	53 (906)

[a] Gonchenaur (1978)
[b] Joffe and Borut (1966)
[c] Scott (2001)
*Maximum reported value in parentheses
ND: Not Detected
NA: Not Available

5.0 CONCLUSIONS

Sporometrics determined that the number and composition of the microflora in the various berm samples are comparable to soil samples colonized by the same or similar species. Most of the fungi were observed at levels within one order of magnitude of those seen in normal household dust in Southern Ontario (Scott, 2001). Please refer to Table 6 above for additional detail.

A. fumigatus, an organism which may pose a potential hazard to human health, was detected in the berm materials at OS&GC and EESA, and in HRC compost. Given the detection of *A. fumigatus* in samples at the OS&GC and EESA berms, it is possible that Sound-Sorb™ (in the absence of compost) may be a potential source of airborne elements of *A. fumigatus*. However, due to the relatively low density of sporulating organisms in the upper layers of the OS&GC berm, it is unlikely that the berm is a major contributor to the aerosol release of *A. fumigatus*. It should be noted that one of samples of HRC compost material contained levels of this organism comparable to those detected in OS&GC surface samples. In the vicinity of the OS&GC, both the HRC and OS&GC may be considered to be potential sources of this organism. As discussed previously, it has been determined that exposure to *A. fumigatus* in healthy individuals does not pose a health risk (Millner *et al.*, 1994).

Sporometrics referenced a paper (Millner *et al.*, 1994) in discussion of the common occurrence of *Aspergillus fumigatus* in compost. **GLOBALTOX** referenced the same paper in discussion of the risk of potential infection from *A. fumigatus* exposure. **Sporometrics** is not aware of established infectious dose values for *A. fumigatus* or any other fungi. Studies from Britain and France found that *A. fumigatus* was the most common species of *Aspergillus* isolated from outdoor air (Domsch *et al.*, 1980). Likewise, viable spore samples from outdoor air of the Southern Ontario region have also been reported. In the indoor environment, *A. fumigatus* is common in trash, house dust and compost (Samson *et al.*, 1996). Important toxic metabolites of *A. fumigatus* include gliotoxin, verrucologen, fumitremorgin A&B, fumitoxins, and tryptoquivalins (Samson *et al.*, 1996). This species is also an important opportunistic human pathogen and the most common agent of aspergilloma and aspergillosis (Ellis, 1976).

E. coli were detected at levels less than US EPA Class B Biosolids criteria in all studies reviewed in Section 3.1, as well as the current study. The highest levels of *E. coli* were detected at levels below the surface of the berm. *E. coli* and *Salmonellae* levels were not analysed in the EESA, HRC or APPL samples. Total coliform levels appear to decrease between the 'stages' of berm construction from fresh PFB (as indicated by the APPL sample), to land-applied Sound-Sorb™. The levels of Total coliform at the OS&GC also appear to be comparable to those detected in the HRC compost. Since the range of levels of Total coliform detected at the EESA and APPL are lower than what was detected at OS&GC, it is possible that the application of compost from the HRC facility contributed to the Total coliform content of the OS&GC berm. Overall, the bacterial flora present in

the berm materials (OS&GC) are unlikely to significantly contribute to bioaerosol formation.

In summary, the following conclusions have been reached based on the results of the current assessment:

1. The potential for the generation of bioaerosols from the OS&GC berm appears to be minimal due to the levels and types of organisms identified;

2. The HRC site may be considered as a potential source of fungal bioaerosols, due to the large areas of visible microbial growth and the results of the surface samples taken during the present study.

6.0 RECOMMENDATIONS

The lack of adequate criteria[6] to evaluate the levels of micro-organisms detected makes it difficult to interpret that data in the context of a hazard assessment. It is recommended that appropriate criteria be established by the MOE, based on a study of typical background levels of fungal and bacterial organisms in soil, or be adapted by the MOE from another jurisdiction. Such criteria would allow for a relevant comparison of levels of micro-organisms determined in this study relative to what may be found in typical Ontario soil.

Air sampling for bioaerosols has not been conducted by the authors of the reports reviewed during this assessment. Since the potential for bioaerosol generation by Sound-Sorb™ is low, **GLOBALTOX** does not recommend that air sampling for bioaerosols be conducted, as it is unlikely that the exercise would produce useful results.

However, in the event that the Bioaerosols Committee requests that air sampling be completed, a sampling strategy should include the detection and quantification of *A. fumigatus*, *A. terreus*, *Cladosporium*, and *Mucor*. The HRC site and the presence of vegetation on the OS&GC berm must both be taken into account in the event of any future bioaerosol sampling, as both media may be potential sources of bioaerosols. Sampling the vegetation growing on the OS&GC berm was out of scope for the current study, however, it should be noted that the combined surface areas of the plant material (leaves and stems) is likely greater than the linear surface area of the berm. Decomposing vegetation is commonly colonized by fungal species such as *Cladosporium* and *Alternaria*, and therefore, this vegetation may potentially contribute to bioaerosol formation.

Additional groundwater sampling should be conducted to examine the PAH content of samples taken from test wells. In particular, levels of benzo(b)fluoranthene,

[6] 'Adequate criteria' would consist of criteria developed for various chemical and microbiological parameters in a comparable medium (eg. paper fibre biosolids).

benzo(k)fluoranthene and benzo(a)pyrene should be monitored, as MOE (2003b) reported levels of these substances in excess of health-based criteria.

7.0 REFERENCES

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